

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, MAY, 1916.

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[Dated: River and Flood Division, Weather Bureau, June 28, 1916.]

FLOODS IN THE UPPER MISSISSIPPI, SPRING OF 1916.

Some account of the floods in the upper reaches of the Mississippi was given in the April, 1916, REVIEW, page 214. Owing largely to circumstances there described, flood conditions continued during May, 1916, being unusually severe between Davenport and the mouth of the Iowa River. Early in April the levees protecting the Illinois side of the river opposite Davenport, Iowa, gave way, and on May 4 the levees protecting Muscatine Island, on the Iowa side of the river, also gave way. By reason of these breaks and the fact that the river continued at a relatively high stage for nearly a month, the inundation proved disastrous to the occupants of the lowlands on both sides of the river.

Approximately 60,000 acres of agricultural land was inundated in the Davenport district, in places to a depth of 12 feet. In a subsequent part of this report the approximate value of the loss occasioned by these floods will be given.

The water which caused the floods in question came principally from the headwaters of the main stream, but a very considerable part was contributed by the Wisconsin River. In the stretch between Keokuk, Iowa, and Louisiana, Mo., the flood conditions were at times intensified by local rains in northeastern Missouri and adjacent portions of Illinois, specially on the 13th and 14th, thus prolonging the period of high water much beyond the usual duration of spring floods.

Notwithstanding the long-continued period of high water between Keokuk, Iowa, and Louisiana, Mo., the Mississippi at St. Louis, Mo., about 100 miles below Louisiana, did not reach the flood stage until the end of the month, as may be seen by the statistics of Table 1.

Approximate loss due to floods in the Upper Mississippi, April–June, 1916.

Tangible property, levees, highways, bridges, factories, etc.	\$164,241
Tangible property of railroads	133,000
Farm property, crops (matured)	110,200
Farm property, crops (prospective acreage, 120,110)	973,950
Live stock and other movable farm property, including buildings	57,100
Suspension of business	80,150
Total	1,518,641
Estimated saving by warnings	1,395,700

FLOOD IN THE LOWER MISSISSIPPI (VICKSBURG DISTRICT), SPRING OF 1916.

By W. E. BARRON, Section Director.

[Dated: Weather Bureau office, Vicksburg, Miss., June 10, 1916.]

First rise.—The relatively high stages that prevailed in the Mississippi River during the summer of 1915 were the subject of much comment; and the lowest stages reached in the autumn were 14.8 feet at Arkansas City, November 15; 10 feet at Greenville, November 15 and 16; and 11.5 feet at Vicksburg, November 17. A rise then set in which culminated early in December, followed by a fall to 21 feet at Arkansas City, on December 17 and 18; 15.7 feet at Greenville, on December 18

and 19; and 18.2 feet at Vicksburg, on December 20 and 21. The rise that immediately followed came out of the Ohio, Cumberland, and Tennessee Rivers. On January 1, 1916, the following stages obtained in the Vicksburg district: Arkansas City, Ark., 40 feet; Greenville, Miss., 32.4 feet; Vicksburg, Miss., 35.6 feet. These are unusually high stages for the opening of the year. The rise continued without interruption until the crest stages were reached, in February, being augmented by two additional rises from the Ohio, one each from the Cumberland and Tennessee, one from the Mississippi above Cairo, and a succession of rises in the Arkansas and White Rivers, which delivered a great quantity of water to the Mississippi in advance of the arrival of the crest of the main stream. The stages that resulted were the highest known, viz., 56.4 feet at Arkansas City, February 10 and 11; 50.7 feet at Greenville, February 11 to 14; 48.8 feet at Lake Providence, La., February 15; and 53.9 feet at Vicksburg, February 15. These stages exceeded those of 1912 by 1 foot at Arkansas City, 0.1 foot at Greenville, 0.6 foot at Lake Providence, and 1.8 feet at Vicksburg, and those of 1913 by 1.3 feet at Arkansas City, 0.3 foot at Greenville, 0.8 foot at Lake Providence, and 1.6 feet at Vicksburg. The highest stage previously recorded at Vicksburg, that of 1897, was overtopped by 1.4 feet. The river was above flood stage at Arkansas City (42 feet) from January 4 to March 15, 72 days; at Greenville (42 feet) from January 18 to March 5, 48 days; and at Vicksburg (45 feet), from January 17 to March 16, 60 days.

The Tallahatchie River at Swan Lake, Miss., reached flood stage (25 feet) during January 9, and continued above flood stage until March 13. The crest was 29.1 feet, February 11 to 14. This rise was due to rains that fell over the Tallahatchie Watershed simultaneously with those over the Mississippi River and tributaries. In the Yazoo River, the highest stage at Greenwood, Miss., which is situated four miles below the confluence of the Tallahatchie and Yalobusha Rivers, was 31.4 feet, or 4.6 feet under the flood stage, February 13 to 17. At Yazoo City, where the run-off from the river is retarded by the backwater effect of the Mississippi, the river reached flood stage (25 feet) on January 28, and continued above flood stage till March 20, a period of 53 days. The highest stage was 29.9 feet, on February 18.

The first flood warning was issued for Arkansas City on December 28, 1915. Warnings of stages of 47 feet at Arkansas City, 40 feet or more at Greenville, and about 45 feet (flood stage) at Vicksburg were issued on January 3, 1916. On January 5, it was possible to forecast stages of 48 to 49 feet at Arkansas City, 42 feet (flood stage) or more at Greenville, and close to 47 feet at Vicksburg. On January 11, forecast was made that the water then in the rivers would give the following stages: Arkansas City, 49 to 50 feet; Greenville, 43 to 44 feet; Vicksburg, 47 to 48 feet. Had these stages been the limit there would have been no marked flood. At the time, practically all of the upper Mississippi and the tributaries were falling, but general rains and snows were in progress, and on the following day (January 12), with a fresh rise in progress throughout the length of the Ohio, the public was advised that these rains would give higher stages than those previously forecast, and delay the crest into February; also, that flood stage would be passed at Vicksburg three days later.

On January 15, the Ohio River having reached its crest at Cincinnati, a warning was issued that the Mississippi would pass 49 feet at Arkansas City, and flood stage at Greenville and Vicksburg by Monday, the 17th, and continue rising until February 3 to 7, reaching 52 feet or more at Arkansas City, 46 to 47 feet at Greenville, and 50 to 51 feet at Vicksburg. On January 19, this was modified by the statement that without further rains it was probable that the lower figures named would not be exceeded. However, heavy rains fell over Arkansas on January 21 and 22, and this estimate was increased approximately one foot at each place.

Another wet period that set in on January 27 over the Arkansas and White Rivers and later spread to the upper rivers further altered the situation, and the forecast was changed from day to day until Monday, January 31, when the public was advised that the continued heavy rains over the watersheds would prolong the rise and give increased stages, passing 55 feet at Arkansas City, 50 feet at Greenville, and 52 feet at Vicksburg. The next day, it was explained that these stages would be reached February 8 to 10, and that a definite forecast of the crest stage was not yet practicable.

On February 3, the following warning was issued:

"Barring breaks in the main line levees, the Mississippi will pass 56 feet at Arkansas City, 50.5 feet at Greenville, and 52.5 feet at Vicksburg by February 8 to 10, and continue rising."

In other words, the public was warned that the flood in progress would overtop all previous high water stages at points in the district. Beyond these stages, the situation was complicated by the discharge of water around the upper end of the Mississippi River levees into the upper Tensas Basin, augmented by breaks in the Arkansas River levees on February 1 and subsequent dates, as well as by the unknown effect of the backwater overflow into the lower Yazoo basin. Hence, on February 5, the information was given out that with the large amount of water then passing out above the end of the Mississippi River levees in Arkansas, the crest at Arkansas City would not be over 56 to 56.5 feet, about February 17, and that if the levees held, Greenville would crest at 50.5 to 51 feet, about February 18, and Vicksburg at 53 to 53.5 feet, about February 20. This forecast was changed on February 8 to 56 feet or slightly over at Arkansas City by February 17, 51 feet or slightly over at Greenville by February 18, and close to 54 feet at Vicksburg by February 19 or 20. The forecast of February 5 proved to be the better for Arkansas City and Greenville, and that of February 8 the better for Vicksburg, though the dates were placed a little too far ahead. As the stages from Arkansas City to Vicksburg were then abnormally high as compared with the stages at Memphis and Helena, the rise that was continuing at those points did not have its normal effect, and the crests at Arkansas City and Greenville were almost coincident with the crest at Helena, when ordinarily they would have occurred several days later.

The rise had almost spent itself at Vicksburg when a crevasse occurred on February 15, in the Buck Ridge levee, 25 miles below Vicksburg, in the New Orleans district. The discharge resulting increased the slope of the water between this crevasse and Vicksburg, and produced a fall of one-tenth of a foot by the following morning. But after this readjustment, the large quantity of water in the lower Yazoo basin held the river at Vicksburg stationary for two days before a steady fall commenced.

Second rise.—By the 1st of April the Mississippi had receded to 34.6 feet at Arkansas City, when another rise began, the result of simultaneous rises in the Ohio, upper Mississippi, Arkansas, and White Rivers. The following stages were reached: Arkansas City, 47 feet, April 20-22; Greenville, 40 feet, April 21-22; Vicksburg, 45.2 feet, April 23-26. The river was above flood stage at Arkansas City (42 feet) from April 9 to May 5, inclusive, and at Vicksburg (45 feet) from April 22 to 28. Ample and accurate warnings for this rise were issued well in advance.

Crevasse and overflow.—On the right bank south of the Arkansas River, the whole of this district is protected by the Arkansas and Mississippi River levees, with the exception of a gap of 2.9 miles between them, through which Cypress Creek flows into the Mississippi River. South of Cypress Creek there is a ridge of comparatively high ground about 12 miles long, known as Amos Bayou Ridge. Under present conditions water begins to flow over this ridge into the upper Tensas Basin at a stage between 51 and 52 feet on the Arkansas City gauge. There were no crevasse in the Mississippi River levees, but several occurred along the Arkansas. Two or three occurred on February 1 in the stretch between Cummings and South Bend, Lincoln County; another on the 3d somewhat farther down at Pendleton, Desha County. Finally, one occurred at Rosemary, on Lake Jefferson, about 5 miles above the open end of the Arkansas River levee. As the territory behind this levee was already overflowed, this crevasse had little effect.

Along the Arkansas, above the end of the levees maintained by the Mississippi River Commission, the overflow from the crevasse amounted to 194 square miles. The water from these crevasse, mingled with the backwater from the Cypress Creek gap, was discharged over Amos Bayou Ridge and spread southward between the Mississippi River and the Little Rock and Alexandria line of the St. Louis, Iron Mountain & Southern Railway, following the courses of the Boeuf River and Bayou Lafourche into the Ouchita, and of Bayou Macon into the Tensas, thence into the Black and lower Red Rivers. The most important towns affected were Arkansas City, Desha County, and Lake Village, Chicot County, Ark. At Arkansas City the water from this overflow reached a height equivalent to a stage of 48.8 feet on the river gauge at that point, or 1.8 feet higher than was reached in 1913. The water was 6 to 8 feet deep in the streets. The area thus overflowed from backwater was 2,247 square miles as compared to 1,591 square miles in 1913, making a total overflow of 2,341 square miles¹ on the right bank from the Arkansas River to the lower limits of this district.

On the left bank of the Mississippi the levees are continuous from the bluffs below Memphis, Tenn., to Eagle Bend, Warren County, Miss., leaving an opening of about 19 miles at the lower end of the Yazoo Basin. During every flood the Mississippi overflows into the lower portion of this basin, and even for a considerable distance above the lower end of the levees. The area of the 1916 overflow in Mississippi was 1,218 square miles,¹ comprising parts of Issaquena, Sharkey, Yazoo, and Warren Counties.

While the excess of the flood heights of 1916 over those of previous years may be attributed to the large quantity of water added by the Arkansas and White Rivers with the levees holding from Cairo to below Vicksburg, it can not be said that the ultimate stages have been reached

in this district, owing to the fact that the gaps at Cypress Creek and at the lower end of the Yazoo Basin have effects similar to those of open crevasse. Should the Cypress Creek gap be closed, or should the levees in Mississippi be extended, gauge heights from Arkansas City to Vicksburg would be more or less increased.

Although there were no crevasse in the Mississippi River levees in this district, and the communities subjected to overflow had ample warning and opportunity to protect much of their property, the losses nevertheless were great, and much inconvenience resulted. Thousands of acres of overflowed territory were fertile farm lands. At Arkansas City, Ark., the water was 6 to 8 feet deep in the streets, and the water and light plants were out of commission.

Opposite the breaks along the Arkansas River the St. Louis, Iron Mountain & Southern Railway was out of commission between Grady and Dumas, a distance of 19 miles, from February 1 to February 10. Farther south in the backwater district, the Arkansas City branch of the same railroad was not in operation between Tripp Junction and Arkansas City (7 miles), from February 1 to February 28, and from Dermott to Halley (6 miles) from February 4 to February 27; the Hamburg branch from Montrose to Luna Landing (19 miles) from February 1 to March 27; while the line running south from McGee, Ark., to Lake Providence, La., known formerly as the Morgan, Helena & Louisiana, was out from McGee to Lake Village, Ark., from February 4 to March 4, and at times as far south as the Louisiana line, a distance of 50 miles.

As the water front at Vicksburg, Miss., is unprotected by permanent levees, and the stage was higher than ever before, the damage locally was correspondingly greater. The stage in the Yazoo Canal at the Government fleet, 3 miles above the Weather Bureau gage, was 1.1 feet higher than that at the latter, which is below the city on the river. Levee Street and the entire local yards of the Yazoo & Mississippi Valley Railroad would have been 1 to 3 feet under water had not the railroad company built temporary levees and lowered the seepage by pumping. Four steam pumps were in operation. This curtailed local property losses and enabled many of the warehouses along the harbor front to continue business. But the railroad company found it necessary to shut down most work at its shops from February 11 to March 6, throwing an average of 325 men out of employment. Other industrial plants used most of their employees in measures for protecting and saving their plants and stocks. At the city waterworks, below town, the water was up to the floor in the pump house.

In the backwater district of Mississippi, railroad train service was continued as long as possible. The Silver City branch of the Yazoo & Mississippi Valley Railroad, a line having a low grade, was closed to traffic between Kelso and George, Miss., on February 3, and the service was not resumed again until March 28. Nearly all of this 27-mile stretch of track was submerged. On the main line of the Yazoo & Mississippi Valley Railroad train service south in and out of Vicksburg was discontinued from February 10 to 26, on account of the depth of water over the tracks in several places. North from Vicksburg to Rolling Fork, Miss., traffic on the main line was discontinued from February 10 to March 1, the track being all under water from Redwood to Rolling Fork, a distance of 32 miles. In the deepest place the water stood 57 inches over the rails. It was over this line that on February 17 Mr. A. H. Egan, superintendent of the railroad, at considerable hazard, brought a special train bearing the Flood Control Committee of the National House of Representatives, the trip being arranged for the purpose of enabling the committee to view the conditions obtaining in the overflowed district. A statement of losses due to the flood follows.

Approximate money loss in Vicksburg district due to the flood of January-March, 1916.

General loss (tangible property).....	\$410,000
Loss of crops (matured).....	70,000
Loss of crops (prospective).....	260,000
Loss of live stock.....	22,000
Suspension of business.....	200,000
Total.....	962,000

In the above table the losses from all sources in this district, outside those of railroads and telegraph lines, are given as \$962,000, and the value of property saved by the warnings of the Bureau is estimated at \$1,650,000. These estimates were made after weighing all reports received. The loss to prospective crops was in small part a loss to oats and other crops already in field at the time of the flood, but in larger measure it was due to the ravages of cutworms, which appeared in the fields that had been planted after the overflow subsided, devastating a vast acreage of cotton and corn and rendering replanting necessary.

The cost of high water protection aggregated \$220,000 for the expenditures of the Government and the State boards in the high-water fight, and probably \$50,000 for private measures, such as building private levees, moving tenants, live stock, and farm products from plantations, and removal of goods to places of safety.

¹ As reported by United States Engineer officers.

Much credit is due to Maj. J. R. Slattery, in charge of the third district office of the Mississippi River Commission, for his able direction of the long-continued fight to hold the levees in this district. While the efforts of the workers were helped by generally favorable weather conditions during the critical period, it is conceded that the successful outcome was due to persistence and the policy of handling the labor situation without the free distribution of rations. The fight was continued until about March 1, when all danger was past.

FLOODS IN OTHER RIVERS.

The rainfall distribution during May both in time and space caused a moderate number of relatively unimportant floods, as may be seen from the statistics given in Tables 2 to 5. From Table 5 it may be noted that neither the Colorado nor the Columbia was in severe flood as a consequence of the heavy snow cover which overlaid mountain tributaries of those rivers.

Floods in western New York.—As Low No. 7, Chart III (XLIV-57), passed slowly northeastward from Iowa, where it was central on the 14th, rain fell almost continuously over western New York and adjacent regions for a period of about four days. The rains on the 14th and 15th were of moderate intensity, but on the afternoon of the 16th a series of thundershowers, some of which were unusually heavy, occurred over the counties of Wyoming, Allegany, Cattaraugus, and Livingston. Doubtless the rains of the two previous days had completely saturated the soil, and accordingly a large portion of the storm waters quickly found their way into the streams. Press reports indicate that watercourses—mere creeks ordinarily—rapidly became swollen rivers, overflowing villages, washing away bridges, damaging railroad tracks and other property. The loss sustained, according to press reports, was close to half a million dollars.

The only river-gaging station in the flooded region was that of Olean, N. Y., on the Allegheny River, where that river rose 11.6 feet in the 24 hours ending on the morning of the 17th. The Genesee River Valley was in the direct course of the storms, and while some apprehension was felt in the city of Rochester, nevertheless the flood wave passed into Lake Ontario without doing serious damage in the lower reaches of the stream.

Daily precipitation, in inches and hundredths, in western New York, May 14-18, 1916.

Stations.	Elevation.	May, 1916.						Total.
		14	15	16	17	18		
Western plateau:	<i>Feet.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	
Alfred.....	1,720	0.17	0.39	2.87	0.75	0.05	4.03	
Allegany.....	1,440	0.06	0.17	0.37	2.35	1.03	3.99	
Angelica.....	1,440	0.00	0.91	2.40	0.79	0.01	4.11	
Avon.....	585	0.06	0.45	2.20	0.86	0.07	3.64	
Bolivar.....	1,800	0.20	0.08	1.85	0.60	0.15	2.88	
Haskinville.....	1,920	(*)	0.34	1.85	1.44	T.	3.63	
Hunt.....	1,150	0.04	1.40	2.53	0.00	0.03	4.00	
Lauterbrunnen.....	1,260	0.11	0.20	3.04	0.72	0.05	4.12	
Olean.....	1,402	0.00	0.20	0.55	2.76	0.14	3.65	
York.....	760	0.11	0.36	4.51	0.54	0.11	5.63	
Great Lakes region:								
Brockport.....	537	0.09	0.64	2.32	0.82	T.	3.87	
Elba.....	750	0.12	0.85	1.83	0.63	0.06	3.48	
Hemlock.....	926	(*)	0.32	4.30	0.10	0.02	5.74	
Perrysburg.....	1,500	0.27	0.25	0.70	0.10	0.10	1.42	
Rochester.....	523	0.08	0.66	2.95	0.02	T.	3.71	
Shortsville.....	660	0.06	0.28	1.60	0.78	T.	2.72	

* Included in next measurement.

The daily amounts of rainfall at cooperative stations in western New York have been supplied by Prof. W. M. Wilson, of Ithaca, N. Y., and appear in the small table above. Similar data for about 100 stations in New York

appear in "Climatological Data, New York Section, May, 1916." The rainfall data show, as has often been shown before, the increasing flood menace which attends moderately heavy rains on saturated ground. Unfortunately no accurate record of the response of the rivers to the storm waters is available, except for the single station before mentioned, but practically all newspaper accounts agree in the statement that the streams rose with remarkable rapidity.

Hydrographs for typical points on several principal rivers are shown on Chart I (XLIV-55). The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

TABLE 1.—Floods in the Mississippi River and tributaries during May, 1916.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		<i>Feet.</i>			<i>Feet.</i>	
Mississippi.....	St. Paul, Minn.....	14.0	1	1	14.1	1
Do.....	La Crosse, Wis.....	12.0	1	5	13.2	1
Do.....	Dubuque, Iowa.....	18.0	1	7	19.8	3
Do.....	Prairie du Chien, Wis.....	18.0	1	2	18.3	1
Do.....	Clinton, Iowa.....	16.0	1	10	18.0	5
Do.....	Davenport, Iowa.....	15.0	3	9	15.9	6
Do.....	Le Claire, Iowa.....	10.0	1	12	12.1	5
Do.....	Muscatine, Iowa.....	16.0	1	11	17.7	7, 8
Do.....	Keokuk, Iowa.....	14.0	1	19	16.4	15
Do.....	do.....	14.0	25	25	14.1	25
Do.....	Warsaw, Ill.....	17.0	1	18	19.4	15
Do.....	Hannibal, Mo.....	13.0	1	31	19.1	16
Do.....	Louisiana, Mo.....	12.0	1	31	17.5	16
Do.....	Quincy, Ill.....	14.0	1	30	18.6	15, 16
Do.....	Grafton, Ill.....	18.0	5	24	20.7	19, 20
Do.....	do.....	18.0	28	(1)	20.8	31
Do.....	St. Louis, Mo.....	30.0	31	(1)	30.0	31
Do.....	Arkansas City, Ark.....	42.0	1	5	44.4	1
Do.....	Vicksburg, Miss.....	45.0			44.5	1
Do.....	Baton Rouge, La.....	35.0			34.5	4
St. Croix.....	Stillwater, Minn.....	11.3	1	12	14.0	1
Do.....	do.....	11.3	23	(1)	13.9	31
Illinois.....	La Salle, Ill.....	18.0	16	25	19.7	18, 19
Do.....	Beardstown, Ill.....	12.0	1	5	12.4	1
Do.....	do.....	12.0	15	31	14.4	31
Missouri.....	Hermann, Mo.....	21.0			20.7	30
Ark.....	Havre, Mont.....	9.0	30	31	9.3	31
Blue.....	Blue Rapids, Kans.....	21.0	14	14	21.5	14
Grand.....	Chillicothe, Mo.....	18.0	14	21	27.0	17
Do.....	do.....	18.0	25	30	25.1	29
Allegheny.....	Olean, N. Y.....	12.0	17	17	13.9	17
Scioto.....	Circleville, Ohio.....	7.0	7	9	9.9	8
Miami.....	Tadmor, Ohio.....	12.0	8	8	13.2	8
Wabash.....	La Fayette, Ind.....	11.0	16	18	13.9	16
French Broad.....	Asheville, N. C.....	4.0	24	24	4.3	24
Cottonwood.....	Emporia, Kans.....	19.5	31	(1)	21.4	31
Neosho.....	Le Roy, Kans.....	24.0			23.0	30

¹ At or above flood stage at close of month.

TABLE 2.—Floods in the rivers of Texas during May, 1916.

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		<i>Feet.</i>			<i>Feet.</i>	
Neches.....	Rockland, Tex.....	20.0	4	10	25.2	6
Do.....	do.....	20.0	24	26	21.3	25
Trinity.....	Fort Worth, Tex.....	20.0			19.8	2
Do.....	Dallas, Tex.....	25.0	2	8	34.8	4
Do.....	Trinidad, Tex.....	28.0	5	15	35.9	12
Do.....	Bridgeport, Tex.....	20.0	1	1	20.0	1
Do.....	Liberty, Tex.....	25.0	Apr. 31	15	27.4	9, 10
Do.....	do.....	25.0	23	31	27.2	23, 30
Colorado.....	Columbus, Tex.....	24.0	23	25	24.0	23
Guadalupe.....	Gonzales, Tex.....	22.0	25	25	22.8	25
Do.....	Victoria, Tex.....	16.0	26	28	18.2	27
Rio Grande.....	San Marcial, N. Mex.....	11.0	Apr.—	(?)	15.3	14

TABLE 3.—*Floods of the South Atlantic and East Gulf States during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		<i>Fect.</i>			<i>Fect.</i>	
Dan.....	Danville, Va.....	8.0	24	34	8.0	24
Roanoke.....	Weldon, N. C.....	30.0	26	26	30.8	26
Santee.....	Rimini, S. C.....	12.0	27	28	12.6	28
Do.....	Ferguson, S. C.....	12.0	6	.....	11.9	29
Saluda.....	Pelzer, S. C.....	7.0	25	25	7.8	25
Wateree.....	Camden, S. C.....	24.0	25	25	24.0	25
West Pearl.....	Pearl River, La.....	13.0	11	12	13.3	11, 12
Do.....	do.....	13.0	26	31	15.2	27

TABLE 4.—*Floods in the rivers of Michigan and New England during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		<i>Fect.</i>			<i>Fect.</i>	
Cass.....	Vassar, Mich.....	14.0	28	29	14.9	29
Tittabawassee.....	Midland, Mich.....	12.0	11	12	12.6	11
Grand.....	East Lansing, Mich.....	7.5	16	18	9.3	17
Do.....	Grand Ledge, Mich.....	6.5	.....	.....	6.4	17
Connecticut.....	White River Junction, Vt.....	13.0	18	19	13.1	18
Merrimac.....	Franklin Junction, N. H.....	13.0	18	18	14.9	18

TABLE 5.—*Floods in the rivers of the Pacific slope during May, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		<i>Fect.</i>			<i>Fect.</i>	
Colorado.....	Topock, Ariz.....	14.0	14	21	17.8	17
Gunnison.....	Sapinero, Colo.....	16.0	8	14	17.8	10, 11
Do.....	Paonia, Colo.....	8.0	6	13	9.1	10
Do.....	Delta, Colo.....	9.0	10	11	9.2	10
Columbia.....	Vancouver, Wash.....	15.0	7	18	18.3	11
Do.....	do.....	15.0	22	26	15.5	24
Clearwater.....	Kamiah, Idaho.....	12.0	7	7	12.2	7
Willamette.....	Portland, Oreg.....	15.0	7	18	18.1	11
Do.....	do.....	15.0	23	25	15.2	24, 25
Kings.....	Piedra, Cal.....	12.0	4	10	12.7	6
San Joaquin.....	Firebaugh, Cal.....	12.0	.....	.....	11.9	13
Do.....	Lathrop, Cal.....	17.0	.....	.....	16.9	9

RAINFALL AND FLOODS IN CHINA.

At the request of the Chinese Government the American Red Cross Society appointed in 1914 a board of engineers, including Col. William L. Sibert, Prof. Daniel W. Meade and Mr. A. P. Davis, to report on a method of preventing or mitigating the great damages caused by the floods of the Hwai-ho (which lies between the Hwang and the Yangtze rivers). Among the party which visited the drainage basin and studied the physical conditions was Mr. S. T. Suen who made a report on the rainfall conditions over the basin and has published an abstract of his paper in the Chinese Students' Monthly for March, 1915.¹

After discussing the causes of rainfall and of floods Mr. Suen takes up the climate and rainfall of China, particularly the latter and bases his study upon the same compila-

tion of data by Louis Froc which Mr. Chu has employed for his study on another page of this issue.

Mr. Suen finds that the intense summer heat of the subtropical southern portion of China maintains the atmosphere there in a state of unstable equilibrium, so that there the convective rainfall accompanying the frequent thunderstorms is heavy.

Again the prevailing summer wind is an east wind heavily loaded with moisture from the Pacific. This moisture is combed out by the mountain ranges close to and paralleling the coast, so that there is a heavy "orographic rainfall" on the windward slopes of the mountains and a correspondingly drier climate farther inland. The westward-pointing rain shadow of these ranges is marked even in the interior.

In addition to the two causes mentioned, and the most fruitful, is the heavy cyclonic rainfall which accompanies the typhoons that frequently visit the southeastern part of China during the summer and fall months.

In general the summer rainfall is much heavier than the winter fall; this is shown also by the maps on pages 280-1. This is particularly the case for the extreme southern and northern regions; the middle, the Yangtze valley, and the coast districts have a more uniformly distributed fall. But a given percentage of the annual fall means three times as much rain in the southern region as it does in the extreme north. The winter precipitation in northern China is very small and usually in the form of snow so that the summer rainfall there, while not as heavy as in the south, makes a preponderating percentage of the total.

Rainfall and flood.—Some Chinese stations have observed 20 to 25 inches of rain resulting from a single storm. Such excessive rain invariably leads to floods. A storm of 5 to 10 inches may be sufficient to produce a flood if the character of the drainage area is favorable thereto; and in the valley of the Hwai-ho floods are frequently brought about even during years of normal rainfall, by reason of the imperfect drainage system. An examination of the map of China will recall to the reader that the lower course of the Hwai-ho labors through the maze of a temporarily abandoned portion of the delta of the Hwang-ho. For example, the flood of July, 1906, in this valley was accompanied by an average fall of 7 inches of rain; in the flood of August, 1910 over the same area, resulting in the famine of 1911, more than 11 inches of rain fell over the drainage area of the Hwai. In In Anhwei and 10 miles north of Pengpu there was a fall of 25 inches in 48 hours during this storm of August, 1910. In the Ohio flood of 1913, the record for half a century of observations, an average of 8 inches of rain in three days fell over the Ohio basin.

A great flood occurred in the Sikiang valley during the summer of [1914], but so far no rainfall reports have been received.

TABLE 1.—*Mean monthly number of storms accompanied by more than 1 inch of rain.*

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tamingfu.....	0.0	0.0	0.4	0.0	0.2	0.4	1.0	0.8	1.4	0.4	0.0	0.0
Weihsueifu.....	0.0	0.0	0.0	0.0	0.0	0.4	1.4	0.6	1.4	0.0	0.0	0.0
Hoklu.....	0.1	0.0	0.4	0.4	0.5	2.1	1.8	0.6	0.5	0.5	0.2	0.0
Chinkiang.....	0.4	0.2	0.5	0.7	0.6	1.6	1.5	1.5	1.0	0.3	0.3	0.0
Hankow.....	0.2	0.4	0.6	1.5	1.8	2.0	1.9	1.0	0.6	0.6	0.4	0.1

¹ Suen, S. T. The causes of rainfall and floods in China. Chinese Students' Monthly, Ithaca, N. Y., Mar. 1915, no. 6, 10:365-377, with 3 figures.